MODELING WITH DATA ASSIMILATION IN THE NORTH ATLANTIC (DAMEE)

David E. Dietrich
Center for Air Sea Technology
Mississippi State University
Building 1103 - Room 233
John C. Stennis Space Center, MS 39529-6000
phone: (228) 688-4218 fax: (228) 688-7100 email: dietrich@cast.msstate.edu
award #: N00014-97-1-0099

LONG-TERM GOALS

To show the strengths and weaknesses of different modeling and data assimilation approaches.

OBJECTIVES

In the past, DAMEE-NAB (Data Assimilation and Model Evaluation Experiment in North Atlantic Basin) experiments have addressed the climatological behavior of different prognostic circulation models as per a fixed list of well documented properties of the North Atlantic Basin. All such experiments have been performed at a low resolution of 1/2 degree with fewer than 20 vertical levels.

Future participants of DAMEE-NAB will address the sensitivity of mesoscale forecasts to variations in climatological measures and will also establish basin-scale predictive capabilities of general circulation models relative to persistence and climatology at higher resolutions. Some other objectives include identifying the strengths and weaknesses of different classes of numerical models and various data assimilation techniques. Exploring and implementing the best data assimilation methods with coupled models would be the final step for accurate, efficient forecasts of the North Atlantic Basin.

APPROACH

The DieCAST model has emerged as being accurate and robust in applications to near-coast features such as boundary currents and shelf break currents and their interactions with deep water eddies. Modeling of such features requires accurate simulation of baroclinic pressure gradient which DieCAST performs successfully, as was found during past studies. More recently, DieCAST has been deployed and validated in different regions of world oceans. Overall, DieCAST has proven to be robust with realistically small diffusivities, unfiltered real topography and realistic density fields. Based on these attributes and past performance, DieCAST will be evaluated with the other general circulation models in DAMEE-NAB experiments for model performance and inter-model comparison.

WORK ACCOMPLISHED

Implemented DieCAST on the standard domain for DAMEE-NAB model comparison experiments. To accomplish intermodel comparison, a modified Arakawa "a" grid version of the DieCAST Ocean model was run on the standard domain for DAMEE-NAB experiments stretching from 6 N to 50 N and from 98 W to 6 W with three degree buffer zones at the

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Modeling with Data Assimilation in the North Atlantic (DAMEE)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Mississippi State University,Center for Air Sea Technology,John C. Stennis Space Center,MS,39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

northern and southern boundary. Ten year simulations have been carried out with data saved from the last three years of the integration for analysis.

Implemented DieCAST at high resolution (1/3 degree) on an extended North Atlantic domain.

Parameter sensitivity studies in NAB. Certain preliminary parameter sensitivity studies have been conducted in the NAB using DieCAST Ocean Model. These include: influence of vertical resolution on the thermocline and other flow features, effect of drag co-efficient on Florida Strait transport and comparison of results with different wind stress Climatologies. A new surface restoring condition which is derived from an atmospheric energy balance model [1] has been implemented and initial results examined.

Thermohaline circulation studies of NAB. The vigorous water mass transformation in the Labrador and GIN Seas must be treated appropriately, because it strongly affects the thermohaline circulation of the entire NAB. This water mass transformation is addressed by: (a) maintaining a diagnostic time mean of model surface heat and salinity fluxes at all horizontal grid points; (b) adding the long term mean model heat and salinity heat fluxes to the surface layer each time step; (c) after adding the long term mean fluxes, restoring to L94 Climatology with O(180) day restoring time scale at each time step; and(d) using the streamfunction for the zonally averaged flow to diagnose thermohaline effects on the meridional circulation

RESULTS

Properties evaluated for performance assessment of the model from results obtained on the standard domain include vertical cross-sections of temperature and salinity (Figs. 1 and 2), Florida Strait transport, SST and SSH means, mean and eddy kinetic energy distributions etc. These diagnostics are obtained from three year time-averaged results from the ten year simulations. They indicate a good agreement with Climatology (Levitus '94) which was used for initialization of the model, even though the open boundaries had to be artificially closed (as per DAMEE-NAB specifications).

A high resolution version of the DieCAST model has also been implemented on an extended NAB domain from 15 S to 75 N and from 98 W to 15 E. The larger domain is desirable to provide more realistic water mass transformation time scales and associated dynamic effects on the NAB thermohaline circulation.

Results show many realistic detailed features (Fig. 3), including: sustained Gulf Stream separation near Cape Hatteras; an active transient eddy field north of the GS with many pinched off warm core eddies; all three branches of the Labrador Current; a prominent persistent anticyclonic Taylor column over the Flemish Cap; a small semi-permanent cyclone pair in the southeastern Flemish Cap region; narrow GS water mass elements that enter a loop current between the cyclonic pair, with the loop regularly pinching off eddies into the Labrador Sea thus ventilating the North Atlantic Gyre in a similar way that LCEs ventilate the Gulf of Mexico; North Brazil Current with retroflection eddies; and a cyclonic western Mediterranean Sea gyre.

To parameterize Arctic Basin water mass transformation, a northern buffer zone along the northern boundary of the modeled region (75 deg N) is used in the high resolution(1/3 deg) model. A northern GS water branch jets to the NE corner of the modeled region, but turns sharply westward in the buffer zone where its water mass is quickly restored toward climatology. An alternative to this short-circuited Arctic water mass transformation is to open the NE corner for

outflow and specify an East Greenland Current inflow (return flow from Arctic basin), which may be implemented later. In the reduced DAMEE-NAB standard domain, Arctic Basin, GIN Sea and Labrador Sea water mass transformations are parameterized by a similar buffer zone near 50 deg N.

IMPACT/APPLICATIONS

A major impact of this research is that it demonstrates that DieCAST realistically simulates detailed coastal and deep water features using lower resolution and significantly less computing than required by other ocean models. This is due to using fully fourth-order accurate numerical schemes, which have very low numerical dispersion, and are uniquely robust with realistic unfiltered topography and realistically small viscosities.

As part of DAMEE-NAB experiments, we expect to shed light on: 1) the strengths and weaknesses of different modeling approaches; 2) NAB water mass transformations and thermohaline circulation, and thermocline and pycnocline structure; and 3) the performance of data assimilation techniques

TRANSITIONS

In FY98 and with continued ONR funding, we hope to deliver diagnostics with and without data assimilation in the North Atlantic Basin for inter-model comparisons, with results submitted to a refereed journal.

RELATED PROJECTS

This project is being directly leveraged by the FY97 ONR Research Grant N00014-97-1-0525 to CAST for Modeling the Santa Barbara Channel Using Realistic Open Boundary Conditions and Winds.

This project is also being significantly leveraged by other ongoing research efforts, both nationally and internationally. For example, Texas A & M University and NRL Stennis are collaborating for general modeling of the Gulf of Mexico using DieCAST, the University of Auckland has adapted DieCAST and its new numerics as the New Zealand Regional Model, the New Zealand Electric Company uses DieCAST for the high resolution Doubtful Sound Model, Dalhousie University is working on adding data assimilation to the DieCAST version in the Gulf of St. Lawrence and Grand Banks Region, NRL Stennis is using DieCAST for high resolution modeling of Adriatic Sea nested within a 1/8 degree Mediterranean Sea DieCAST model and for coupled Ice-Sea Modeling in the Arctic, Bedford Institute of Oceanography is investigating DieCAST performance in coastal zones and in the North Atlantic, NOAA National Marine Fisheries Service has used DieCAST in the Gulf of Mexico to study algal blooms, University of New South Wales, Sydney, Australia is using DieCAST to run simulations for the East Australian Current and Tasman Sea, Australian Defense Forces Academy is running simulations in the Hawaiian Island area using DieCAST, NOAA Great Lakes Environmental Research Laboratory has configured DieCAST to run simulations in Lakes Erie and Michigan, Memorial University is using DieCAST for simulations in Newfoundland Bay, Florida State University has coupled DieCAST to an atmospheric model to investigate hurricane response, MIT and Canadian Meteorological Center have coupled DieCAST to the Canadian operational meteorological model, and Oregon State University is developing high resolution Southern Hemisphere and global scale versions of the DieCAST Ocean Model. Some other collaborations involve James Cook University, University of

Trieste in Italy, UIB at Palma in Spain, Government of Bulgaria, University of Otago and Leigh Laboratory in New Zealand, and CSIRO in Australia.

REFERENCES

1. Rahmstorf, S. and J. Willebrand (1995). The Role of Temperature Feedback in Stabilizing the Thermohaline Circulation. J. of Phys. Oceanography, May 1995, pp. 787-805.

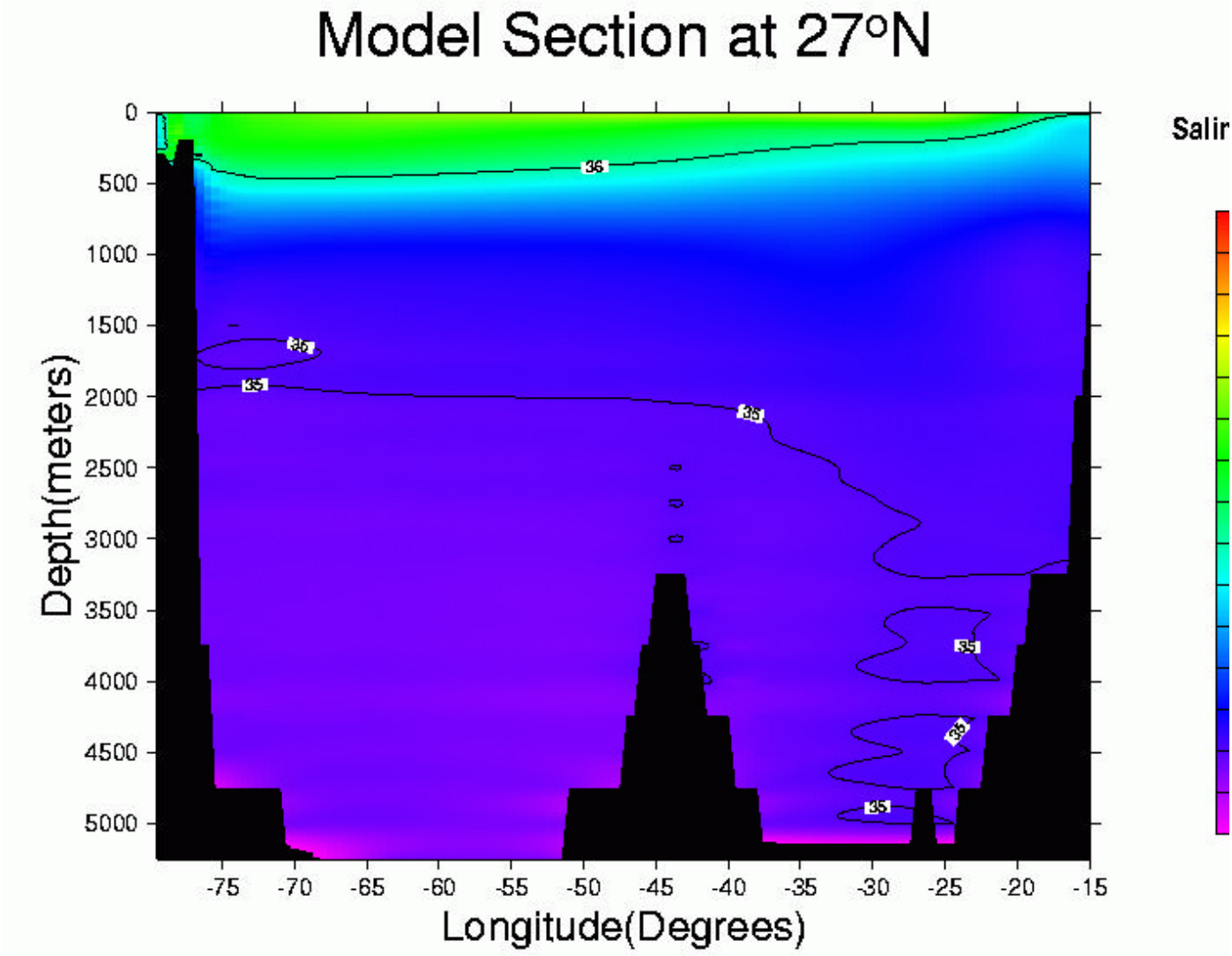

Figure 1. Time-averaged results from the last three years of integration of a ten year simulation of DieCAST NAB model at one-half Degree resolution. The model domain was the prescribed standard domain set for DAMEE-NAB experiments .

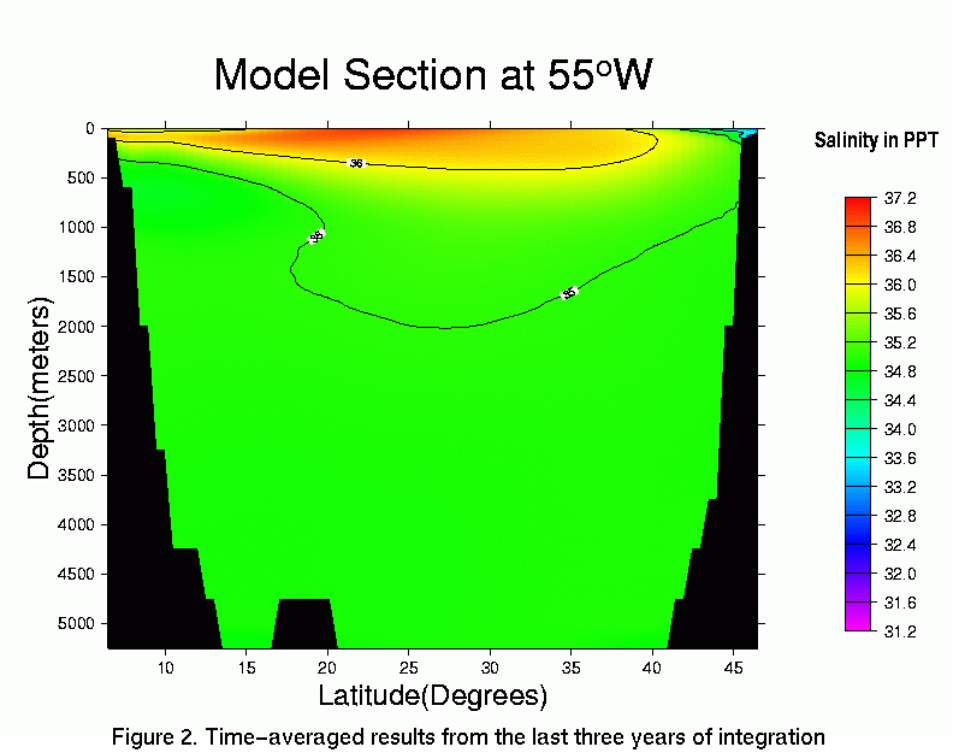

Figure 2. Time–averaged results from the last three years of integration of a ten year simulation of DieCAST NAB model at one–half Degree resolution. The model domain was the prescribed standard domain set for DAMEE–NAB experiments.

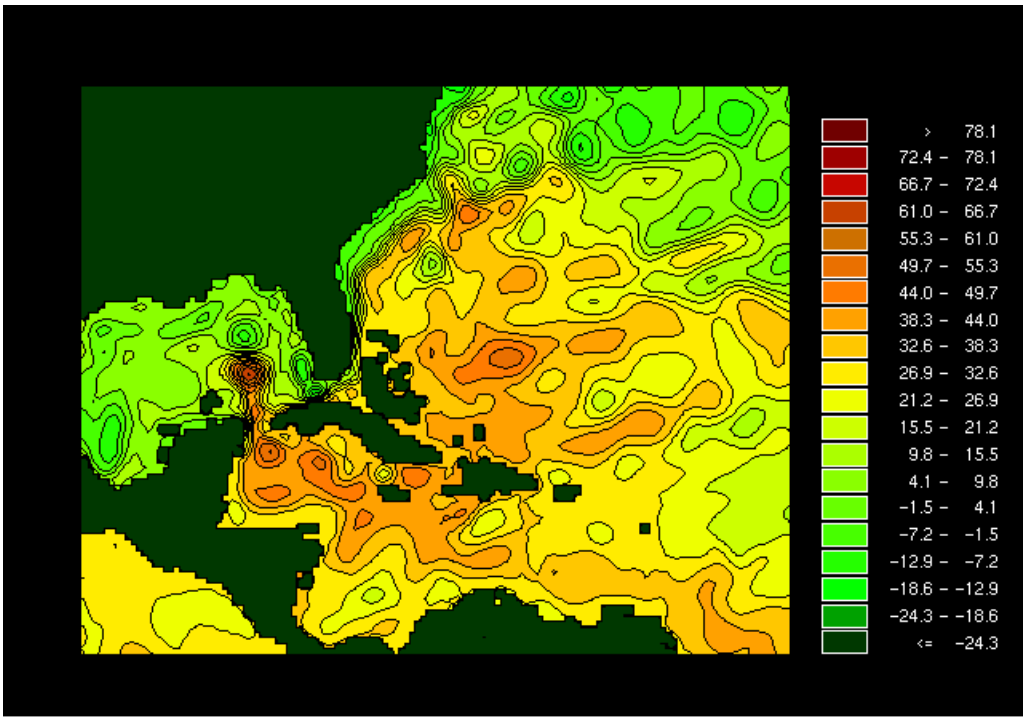

Figure 3. Equivalent Sea Surface Height(in cms) contours at Day 2580 from the extended (1/3) Degree DieCAST NAB model. A developing Loop Current Eddy in the Gulf of Mexico is seen along with a separating Gulf Stream at Cape Hatteras.